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Published in THE PRAIRIE NATURALIST 36(4): December 2004
Published by the North Dakota Natural Science Society.

Roadside Bias in Point Count Surveys at Arrowwood National Wildlife Refuge, North Dakota

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ABSTRACT -- We investigated potential biases of using roadside point counts to sample breeding bird populations in the northern mixed-grass prairie. In 1995, a breeding bird inventory and monitoring program was initiated at Arrowwood National Wildlife Refuge, east-central North Dakota. Surveys were conducted annually through 1998 from an extensive point count array permanently located across the refuge (n = 162). Fifty-nine percent of the point counts were established directly on tertiary dirt roads and trails, while the remaining were interspersed at randomly selected distances of 100, 200, 300, and 400 m away from roads. Roadside point counts commonly consisted of a mosaic of habitat types, partly due to the inclusion of woodlands (riparian, shelterbelt or farmstead groves) and wetlands. The number of bird species observed at point counts tended to be greater on-road and the effect did not differ over time. Relative abundance estimates for most commonly observed species were not related to distance from road, either spatially or temporally. Only the relative abundance of savannah sparrow (*Passerculus sandwichensis*), grasshopper sparrow (*Ammodramus savannarum*), and western meadowlark (*Sturnella neglecta*) was associated with distance from road, but the effect was small ($R^2 < 0.06$). In addition, there was little evidence that the annual variation in counts was related to distance from the road, which suggested that trend estimates derived during a population-monitoring program from roadside counts would not differ from off-road counts at Arrowwood National Wildlife Refuge.

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Key words: breeding birds, monitoring, point counts, relative abundance, roadside bias, species richness.

Secondary and tertiary road systems are used commonly as the point-count transect to inventory and monitor bird populations. The use of roads expedites travel between survey stops because surveyors can cover broad geographic areas efficiently. Concerns over potential biases of roadside point counts have been raised (Ralph et al. 1995), although relatively few published studies have addressed this issue. Potential biases can take several forms, depending on the type of the road system employed, including the influence of vehicle traffic noise on bird populations (Reijnen et al. 1995), habitat discontinuities created by roads (Hanowski and Niemi 1995, Hutto et al. 1995, Keller and Fuller 1995, Rotenberry and Knick 1995, Sutter et al. 2000), habitat changes along roads that might differ from those in the geographic area of inference (Bart et al. 1995, Keller and Scallan 1999), and whether habitats sampled were of similar proportions on roads to that of the geographic area of interest (Hanowski and Niemi 1995, Keller and Scallan 1999).

We evaluated a four-year bird monitoring dataset to (1) determine if habitat types were sampled equally by using on- and off-road point counts, and (2) determine if bird species richness and relative abundance varied within and across years according to point count location relative to the distance from roads.

METHODS

The data used for our analysis were collected at Arrowwood National Wildlife Refuge (NWR), located along the James River in Foster and Stutsman counties in east-central North Dakota (47°26'N, 98°86'W; elevation ca. 450 m). The refuge lies on the western edge of the Drift Prairie, where the topography is characteristic of glacially created plains, with terrain that ranges from mildly undulating to hilly. Native mixed-grass prairie was the principal upland habitat at Arrowwood NWR, followed by seeded grasslands, croplands, and woodlands. Grassland vegetation was dominated by nonnative species, including Kentucky bluegrass (*Poa pratensis*), smooth brome (*Bromus inermis*), and leafy spurge (*Euphorbia esula*). Native grasses included western wheatgrass (*Pascopyrum smithii*), needle grasses (*Stipa* spp.), little bluestem (*Shizachyrium scoparium*), and blue grama (*Bouteloua gracilis*). Wheatgrasses (*Agropyron* spp.), alfalfa (*Medicago sativa*), and sweet clover (*Melilotus officinalis*) were the principal species seeded for dense nesting cover. Western snowberry (*Symphoricarpos occidentalis*) was a common encroaching native shrub in grassland habitats. Woodland habitats were mostly riparian, but also occurred as shelterbelt and farmstead groves. Common riparian trees included green ash (*Fraxinus*

pennsylvanica), American elm (*Ulmus americana*), and box elder (*Acer negundo*). Shelterbelts commonly possessed green ash, Russian olive (*Elaeagnus angustifolia*), Siberian elm (*U. pumila*), Rocky Mountain juniper (*Juniperus scopulorum*), choke cherry (*Prunus virginiana*), and Siberian pea-shrub (*Caragana arborescens*).

Permanent survey points (n = 162) were selected by using a systematic-random design along tertiary dirt roads that networked throughout the refuge. The road system surveyed consisted of two-tracked roads with both gravel and native surfaces (grass or dirt). Both types had slightly raised crowns in sections; none were bordered by ditches. Ninety-five point counts were located on roads, while 67 were interspersed at randomly selected distances of 100, 200, 300, and 400 m from roads. Point count centers were placed greater than or equal to 200 m apart.

Bird populations were surveyed by using fixed-radius point counts (Hutto et al. 1986). This method assumes that detection probabilities for each species are constant over time and space (Barker et al. 1993). Surveys were standardized to control for season, observer, count duration, time of day, and weather (Dawson 1981, Hutto et al. 1986). Surveys were conducted once annually during June from 1995 through 1998, though surveys continued into mid-July in 1996 due to wet and windy conditions. One trained observer conducted all surveys in all years. Each point count was surveyed for a 5-min period beginning immediately upon arrival, whereupon all birds seen or heard within a 100-m distance from the point were recorded during the count period. Surveys began 15 to 30 min prior to local sunrise and typically lasted until 0930 to 1000 hr CDT. Surveys were not conducted during periods of inclement weather (e.g., rainy conditions or winds greater than 24 km/hr).

The percent cover of habitat types occurring in each point count was estimated in the field and verified by using aerial photographs. Six habitat types were used: 1) native mixed-grass prairie, 2) seeded tame grass, 3) alfalfa hayfields, 4) cropland (small grains or row crops), 5) wetlands, and 6) woodlands.

Statistical analyses were conducted by using SPSS Release 10.5 (SPSS Inc. 1999). We used simple correlation coefficients to gauge the relationship between distance from road and the proportion of each cover type (Spearman r_s), and presence of more than one habitat cover type within the boundaries of a given point count (Pearson r). Using multivariate analysis of variance with a repeated measures design (Norusis 1990), bird species richness and relative abundance (number of detections/point count) were treated as response variables and tested for road effects (using distance from road as a covariate), year effects (four years), and road-year interactions. Strength of association (effect size) for each effect was characterized by using the proportional reduction in error measure, R^2, which is interpreted as the proportion of the variation in species richness or abundance accounted for by the variation in distance from road or year (Agresti and Finlay 1986). Values fall between 0 and 1, with larger values indicating greater association. Significance level for all statistical tests was set at an α-level of 0.05.

RESULTS

Native mixed-grass prairie was the dominant habitat, covering on average 64% (SE = 3) of each point count area, which significantly increased with distance from road (r_s = 0.194, P = 0.017, n = 152). Conversely, % wetland and woodland coverage declined significantly with distance from road (Table 1). We observed a negative relationship (r = -0.413, P = 0.000, n = 161) between distance from road and the probability of a point count having multiple habitat types. Fifty-eight percent of the point counts consisted of multiple habitats on-road, while only 6% of the point counts located 400-m off-road had more than one habitat type.

We observed a total of 75 bird species during the survey. Passerines (38 species) and waterfowl (10 species) were the dominant taxa. Clay-colored sparrow (*Spizella pallida*) was detected most often, accounting for over 15% of all individuals counted. Other dominants included brown-headed cowbird (*Molothrus ater*) (11%), red-winged blackbird (*Agelaius phoeniceus*) (9%), bobolink (*Dolichonyx oryzivorus*) (7%), common yellowthroat (*Geothlypis trichas*) (5%), and sedge wren (*Cistothorus platensis*) (5%). Mallard (*Anas platyrhynchos*) was the most common waterfowl species recorded (2%).

Bird species richness per point count decreased significantly with distance from road (R^2 < 0.076, n = 156). Controlling for distance from road, species richness also varied significantly among years. However, no significant interaction between year and distance from road was observed (R^2 = 0.003, P = 0.690), which suggested that patterns in species richness over time did not differ according to the location of point counts relative to roads. Similar patterns were observed for relative abundance parameters for common species (Table 2). A significant road effect was found for savannah sparrow (*Passerculus sandwichensis*), grasshopper sparrow (*Ammodramus passerculus*), and western meadowlark (*Sturnella neglecta*), but the relationship was small (R^2 < 0.06, n = 156). Eleven of the 21 species examined showed significant year effects in abundance, but only the common yellowthroat and western meadowlark had significant road-year interactions, although the effects were small (R^2 < 0.06).

DISCUSSION

Potential biases of conducting bird surveys that use roadside point counts have become topical (Ralph et al. 1995), with implications to the inferential capabilities of national, regional, and local monitoring schemes that use this survey method. Several studies have examined the direct influence of roadsides on estimates of population attributes. Rotenberry and Knick (1995) found little indication of a roadside count bias in shrubsteppe and grassland habitats in

Table 1. Mean proportion of cover types at each point count according to distance to road, and the relationship (Spearman r_s) between distance from road and the proportion of each cover type at a point.

	Distance from road (m)							
Cover type	0	100	200	300	400	r_s	P	n
Native prairie	0.60	0.78	0.66	0.77	0.68	0.194	0.017	152
Tame grass	0.11	0.05	0.20	0.08	0.24	0.026	0.749	152
Alfalfa	0.03	0.00	0.04	0.00	0.03	-0.063	0.440	152
Cropland	0.08	0.00	0.02	0.15	0.06	-0.147	0.070	152
Wetlands	0.03	0.01	0.00	0.00	0.00	-0.196	0.016	152
Woodland	0.14	0.17	0.08	0.00	0.00	-0.190	0.019	152
Habitat mosaic[a]	0.58	0.25	0.25	0.07	0.06	-0.413[b]	0.000	161

[a]Point count area consisted of more than one habitat type.
[b]Pearson correlation coefficient.

southwestern Idaho, except that the western meadowlark was observed more commonly along roads. They attributed this to what they referred to as a "fence effect", where the western meadowlark conspicuously perches on fences that commonly border roads in western rangelands. This likely explains why the western meadowlark was observed more commonly at roadside points in our study, although effect varied across years. At Arrowwood NWR, 52% of roadside points had a fence within the survey area versus 20% for off-road points.

Studies of road bias in surveys of forested habitats commonly derived greater species richness and abundance estimates on roads, particularly for forest edge species (Hanowski and Niemi 1995, Hutto et al. 1995, Keller and Fuller 1995). They generally attributed the effect to habitat changes associated with the presence of roads (and also the possibility of increased detectability), and that this could be mitigated somewhat by choosing narrower secondary roads, and by restricting point counts to specific habitats of interest. The road system at Arrowwood NWR consisted mostly of non-graveled trails in typically open grasslands, and as such, we assumed that roads themselves had little direct impact on estimates of bird community parameters. However, there is the potential for bias in the geographic placement of roads that might sample disproportionately some habitats over others. In the northern Great Plains, secondary roads commonly divide areas of different land ownership, and therefore, possibly different land-use practices. We observed this to some degree at Arrowwood NWR, where roadside point counts

Table 2. Mean relative abundance (number of detections/point count) of bird species detected in on- and off-road points, and the effect of distance from road on relative abundance and species richness. (R) denotes a significant road position effect, (Y) denotes a significant year effect, and (R-Y) denotes a significant road-year interaction on relative abundance and species richness (n = 156).

	Distance from road					
Species	0	100	200	300	400	R^2
Gadwall (*Anas strepera*)	0.1	0.0	0.1	0.2	0.1	0.000 Y
Mallard (*A. platyrhynchos*)	0.2	0.3	0.2	0.5	0.2	0.002 Y
Mourning dove (*Zenaida macroura*)	0.2	0.3	0.1	0.1	0.1	0.014 Y
Willow flycatcher (*Empidonax traillii*)	0.1	0.4	0.1	0.2	0.1	0.001 Y
Least flycatcher (*E. minimus*)	0.1	0.1	0.1	0.0	0.0	0.008 Y
Western kingbird (*Tyrannus verticalis*)	0.1	0.2	0.1	0.0	0.0	0.024
Eastern kingbird (*T. tyrannus*)	0.3	0.4	0.3	0.2	0.2	0.024
Tree swallow (*Tachycineta bicolor*)	0.3	0.2	0.1	0.3	0.1	0.020
Sedge wren (*Cistothorus platensis*)	0.6	0.4	0.8	0.6	0.4	0.007
Yellow warbler (*Dendroica petechia*)	0.5	1.0	0.2	0.3	0.2	0.023
Common yellowthroat (*Geothlypis thichas*)	0.6	0.5	0.6	0.6	0.7	0.002 Y, R-Y
Clay-colored sparrow (*Spizella pallida*)	1.7	2.0	1.8	1.6	1.4	0.004
Savannah sparrow (*Passerculus sandwichensis*)	0.4	0.3	0.8	0.3	1.0	0.049 R, Y
Grasshopper sparrow (*Ammodramus savannarum*)	0.4	0.2	0.8	0.3	0.7	0.036 R

Table 2, continued.

	Distance from road					
Species	0	100	200	300	400	R^2
Song sparrow (*Melospiza melodia*)	0.3	0.2	0.2	0.3	0.1	0.016
Bobolink (*Dolichonyx oryzivorus*)	0.7	0.8	0.8	0.7	1.1	0.023
Red-winged blackbird (*Agelaius phoeniceus*)	1.1	0.9	0.6	1.5	0.8	0.002 Y
Western meadowlark (*Sturnella neglecta*)	0.2	0.1	0.2	0.1	0.1	0.059 R, Y, R-Y
Common grackle (*Quiscalus quiscula*)	0.4	0.6	0.5	0.4	0.0	0.013
Brown-headed cowbird (*Molothrus ater*)	1.5	1.3	0.8	1.2	0.8	0.009 Y
American goldfinch (*Carduelis tristis*)	0.3	0.4	0.2	0.2	0.2	0.005 Y
Species richness	6.4	6.1	5.8	5.3	4.9	0.080 R, Y

were more likely to consist of a mosaic of habitats. In addition, isolated woodland habitats were more prevalent along roads in the form of shelterbelts and riparian habitats. Wetlands also were more prevalent along roads at Arrowwood NWR, but to a lesser degree. This is partly because roads here also serve as dikes for several small and large drainages. In addition, the area between the impoundments and road edge can be quite narrow, which often puts the riparian zone within the point count on the road.

Regardless of habitat biases observed here, there was in practical terms, little road effect on abundance estimates for the common bird species, or in abundance patterns over time. The latter is supported by the lack of significant interactions between distance from road and year, which suggested that patterns in counts over time differed little according to point count location relative to roads. Although species richness was greater near roads, which likely was related to greater habitat diversity encountered there, there was no evidence that the effect varied over time. These results suggested that on-road trend estimates derived during population monitoring would be similar to those generated off-road at Arrowwood NWR.

The generality of these results is worth exploring in the northern mixed-grass prairie. Although the study area was located in eastern North Dakota,

our habitat configuration probably more resembles that of the Missouri Coteau in central North Dakota. Here, we suspect that a similar habitat bias would occur along secondary roads. Moreover, secondary roads in central North Dakota are generally two to three times wider than those in our study, and are often bordered by steep ditches that might provide grassland and/or wetland habitat that would otherwise not be present in adjacent fields. As conditions become increasingly dryer proceeding west, both woodlands and wetlands decline in distribution, while rangeland becomes increasingly predominate, thus we might expect even less road bias in habitats sampled there than that found in eastern North Dakota.

ACKNOWLEDGMENTS

Funding for our project was provided by U. S. Fish and Wildlife Service Arrowwood National Wildlife Refuge and Region 6 Nongame Migratory Bird Program. L. Igl and D. H. Johnson assisted with the study design. We thank J. Bart, S. K. Davis, E. J. Finck, S. L. Jones, and C. M. E. Keller for helpful comments on earlier drafts of our manuscript.

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Received: 15 October 2003 *Accepted: 30 November 2004*